Long-Term Monitoring and Maintenance Plan Lower Passaic River Study Area

River Mile 10.9 Removal Action

January 2017, Rev. 4

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Cooperating Parties Group
Newark, New Jersey

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AOC	Administrative Settlement Agreement and Order on Consent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
COPC	chemical of potential concern
CPG	Cooperating Parties Group
D_{50}	median diameter
GPS	global positioning system
LPR	Lower Passaic River
LPRSA	Lower Passaic River Study Area
LTMMP	Long-Term Monitoring and Maintenance Plan
NCP	National Contingency Plan
PAC	powdered activated carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PDMS	polydimethylsiloxane
QAPP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/Feasibility Study
RM	river mile
SOP	standard operating procedure
SPME	solid-phase microextraction
TCDD	tetrachlorodibenzo-p-dioxin
TCRA	Time-Critical Removal Action
TOC	total organic carbon
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1.0 Introduction

This Long-Term Monitoring and Maintenance Plan (LTMMP) for River Mile (RM) 10.9 of the Lower Passaic River Study Area (LPRSA) has been prepared pursuant to the Administrative Settlement Agreement and Order on Consent (AOC) for Removal Action, Docket No. 02-2012-2015 (United States Environmental Protection Agency [USEPA] Region 2, 2012a), by the Cooperating Parties Group (CPG). The RM 10.9 AOC became effective on June 18, 2012.

The Removal Action was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) as a Time-Critical Removal Action (TCRA). The Removal Action selected by the USEPA Region 2 (Region 2 hereafter), which included removal of contaminated sediments by dredging followed by placement of an engineered reactive cap, is presented in the Action Memorandum/Enforcement dated May 21, 2012 (USEPA Region 2, 2012b).

This RM 10.9 LTMMP is being implemented to monitor the protectiveness and integrity of the engineered reactive cap. The monitoring activities to be conducted include both routine and event-based physical monitoring and routine chemical monitoring as discussed herein. This RM 10.9 LTMMP was developed specifically for monitoring and maintaining the RM 10.9 cap. The requirement for routine chemical monitoring of the RM 10.9 cap was developed at the direction of Region 2. This RM 10.9 LTMMP and its monitoring techniques, sampling density, and frequency do not necessarily reflect the long-term monitoring approach that will be applied to the entire 17-mile Lower Passaic River remedy including the RM 10.9 Removal Area.

This LTMMP has been updated from the prior version submitted to Region 2 (CH2M Hill, 2013a) to incorporate chemical monitoring, to assist with evaluations on whether the engineered cap is functioning as designed. This version is also amended to include the RM 10.9 Post-Construction Monitoring Quality Assurance Project Plan (QAPP) prepared by the CPG (AECOM, 2017) at the direction of Region 2. The QAPP, which is included as Appendix A of this LTMMP, was prepared for the first monitoring event initiated in 2015 (approximately one year after cap completion) and extending into 2016 and a second event to be conducted approximately five years after cap completion. The QAPP will be updated for the subsequent events, as necessary, based on the results of previous monitoring events and potential advancements in cap monitoring technologies and techniques as long as the modifications allow for comparability with existing data.

1.1 Project Description

The goals of the Removal Action at RM 10.9 were to reduce exposure to elevated concentrations of the primary classes of chemicals of potential concern (COPCs), including polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans (PCDDs/PCDFs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and mercury, in the removal area and to prevent migration of contamination from the removal area to other parts of the LPRSA. The Removal Action implemented at RM 10.9 included mechanical dredging of approximately 16,000 cubic yards of surface sediment (top 2 feet) followed by placement of an engineered cap over the removal area. This work was completed in May 2014. The engineered cap, which includes an activated carbon amendment in the sand isolation layer and an armor layer, was designed to be both chemically and physically protective for over 100 years. Dredged sediments were transported to a permitted off-site facility for treatment via stabilization and stabilized sediments were transported to a permitted out-of-state disposal facility.

A small portion of the RM 10.9 Removal Area shoreline (i.e., the northeastern most end of the removal area) contains rock with pockets of sediment. While the original TCRA design (CH2M Hill, 2013b) determined that these areas could not be capped due to the grade of the existing slope, additional field investigation also indicated this area could not be dredged without removing the rock armor and potentially destabilizing the slope. Thus, Region 2 agreed not to dredge or cap this small portion of the removal area and instead to address it as part of the larger river remedy. As further discussed in Section 2.4, dredging and capping were conducted in high sub-grade areas near shore where sediments were present above rock armor and hardpan material. The high sub-grade areas are areas near shore where the full 2 feet of sediment could not be excavated prior to placing the cap due to rock armor and hardpan material. The Jersey City Municipal Utilities Authority identified and agreement was reached for a dredging offset of 30 feet from each of the two potable water supply lines that transect the RM 10.9 Removal Area in its May 2, 2013 letter to the CPG's contractor.

1.2 Site Background

The RM 10.9 Removal Area, which is a portion of the RM 10.9 Study Area (Figure 1), is located on the eastern side of the LPRSA extending from RM 10.7 to RM 11.2. It is situated along an inside bend of the Lower Passaic River (LPR), upstream of the DeJessa Park Avenue Bridge, and includes the mudflat and point bar in the eastern half of the river channel. The Removal Area is bounded to the west by the navigation channel of the Passaic River and to the east by the Riverside Park complex in Lyndhurst, New Jersey. Sediment has been dredged, and an engineered cap was subsequently placed, within approximately 4.3 acres of the RM 10.9 Removal Area (Figure 2).

The Final Design Report (CH2M Hill, 2013b) contains detailed site information on the nature and extent of impacted sediments containing elevated concentrations of PCDDs/PCDFs and other COPCs, as well as the dredge and cap design criteria and the engineering design drawings and specifications.

2.0 Cap Design and Construction Summary

As part of the Removal Action, a cap was placed on the post-dredge sediment to physically and chemically isolate the remaining sediment COPCs from the environment by means of chemical containment and erosion protection. The key components of the cap, as presented in Figure 3, include a sand/active layer overlain by geotextile fabric and a top armor layer with a thin layer of sand covering the top of the armor stone. Summaries of the cap design elements are presented below in Sections 2.1 through 2.3 and are discussed in more detail in the Region 2-approved RM 10.9 Final Design Report (CH2M Hill, 2013b). Summaries of the design modification to the cap due to high sub-grade and rocky areas (see "Hard Pan" areas [purple hatching] in Figures 2, 4 and 5) and the cap construction (as-built conditions), as documented in the RM 10.9 Removal Action Final Construction Report (CH2M Hill, in preparation), are presented below in Sections 2.4 and 2.5, respectively.

2.1 Active Cap Layer

The lower portion of the cap, which serves as the chemical isolation layer, consists of sand mixed with the active material (i.e., activated carbon amendment to enhance chemical sequestering) to form a combined sand/active layer. The cap's active material consists of AquaGate+PAC™ (powdered activated carbon) composite particles containing 10 percent activated carbon manufactured by AquaBlok® mixed with sand over a 10-inch layer to form a combined sand/active layer containing an average of 30 percent and a minimum of 25 percent active material by volume. The minimum (25/75) AquaGate+PAC™ and sand blend corresponds to an activated carbon concentration of approximately 1.8 percent by weight and 2.5 percent by volume.

As discussed further in the Final Design (CH2M Hill, 2013b) and technical memoranda, cap modeling using CapSim Version 2.6 (based on site-specific upwelling data as well as porewater data collected from underlying sediment in areas with the highest concentrations of COPCs) for an isolation layer thickness of 10 inches and an amendment dosage based on 25 percent active material by volume predicted no breakthrough for well over 100 years for 2,3,7,8 - tetrachlorodibenzo-p-dioxin (TCDD), PCB-52 (surrogate for total PCBs), and phenanthrene (surrogate for total PAHs). The CapSim model simulated a bulk density of activated carbon in the active layer of 0.026 g/cc based on this 25/75 percent blend of AquaGate+PAC™ and sand mixture. During construction, placement of an active layer at a 30/70 percent blend of AquaGate+PAC™ and sand ensured that the minimum dosage as represented in the cap model (based on a 25/75 percent blend) was attained. Details of cap construction monitoring are presented in the RM 10.9 Removal Action Final Construction Report (CH2M Hill, in preparation).

2.2 Physical Separation Layer

A geotextile (nonwoven 100 percent plastic high-strength dimensionally stable filter fabric) was placed between the sand/active layer and the armor layer. The function of the geotextile was to protect the sand/active layer during placement of the armor layer and to prevent the sand/active layer from being eroded or gouged by the protective stone layer.

2.3 Armor Layer

The top armor layer is designed to prevent erosion of the cap material during high river flows and other forces. The 12-inch-thick armor layer consists of various sizes of stone with a median diameter (D_{50}) of 4.5 inches. Following placement of the armor stone, sand was placed over the stone to fill in the spaces between the stones to create a smooth surface on the top of the armor layer. The armor layer design is based on preventing cap erosion from an LPR flow of 22,000 cubic feet per second (cfs) as measured at Little Falls, which is the 100-year return period flood flow. Use of the 100-year return period flood for the design is consistent with recommendations in USEPA (2005) guidance and other cap designs; however, the cap is expected to remain generally intact even if the 100-year return period flow is exceeded. The velocity and associated erosive forces across the River are not uniform; the highest velocities used for design occur over only small portions of the cap. Thus, the vast majority of the cap, especially the cap placed in the shallower water depths, is expected to withstand flows that are higher than the 100-year return period flood.

2.4 High Sub-grade Areas

A revised cap design was developed and utilized for placement in high sub-grade areas near shore where the full 2 feet of sediment could not be excavated prior to placing the cap due to rock armor and hardpan material (see "Hard Pan” areas in Figures 2, 4 and 5). To ensure the elevation of the top of the cap would be less than the original sediment surface, the cap design required modification to reduce its thickness in those areas. The revised cap design (see Cap Type B in Figure 3) consisted of an average of 6 inches or more of active material (i.e., the same AquaGate+PAC™ and sand mixture as the standard RM 10.9 “Type A” cap design as described in Section 2.1), geotextile, 6 inches of Type B (D_{50} = 2 inches) armor stone, and sand placed over the stone to fill in the spaces between the stones to create a smooth surface on the top of the armor layer. Based on cap modeling results presented in the Technical Memorandum for the High Sub-grade Cap Design included in the Final Construction Report (CH2M Hill, in preparation), the revised cap design for this area was determined to be fully protective for those conditions in near-shore areas (i.e., water depths less than 3-feet-deep) with a high sub-grade.

These high sub-grade areas are not representative of the overall RM 10.9 cap as the high sub-grade is only a minor portion of the remediated area and this cap type covers only thin amounts of residual sediment with lower concentrations of COPCs as documented in the post-dredge samples. Therefore, these high sub-grade areas will not be chemically monitored.

2.5 Cap Construction Summary

As documented in the RM 10.9 Removal Action Final Construction Report (CH2M Hill, in preparation), the design-specified minimum thickness and minimum average thickness were achieved on a site-wide basis for both the active layer and armor layer. The average thicknesses of the active layer and armor layer in the Type A cap were 10.5 and 15.2 inches, respectively. In addition, approximately 6 inches of sand were placed on the cap as a habitat layer to fill the voids in the armor stone and to provide a relatively smooth cap surface with a design goal of no net increase in cap elevation above the armor layer.

As noted above in Section 2.4, the cap design in areas near shore where hard sub-grade was encountered was modified with the approval of Region 2 and the average thicknesses of the active layer and armor layer were each approximately 6 inches (Type B cap).

In addition, the minimum activated carbon dosage as represented in the cap model (based on a 25/75 percent blend of AquaGate+PAC™ and sand) was achieved throughout the cap area based on material ratio testing conducted by the engineer and contractor (as documented in Appendices B and H of the Final Construction Report). Approximately 1,800 tons of AquaGate+PAC™ were placed with approximately 4,300 cubic yards of sand in the active layer.

Additional details on cap construction can be found in the RM 10.9 Removal Action Final Construction Report (CH2M Hill, in preparation).

3.0 Cap Monitoring Objectives and Approach

Long-term monitoring of the engineered cap will be performed to confirm that the cap is functioning as designed. This section presents a summary of the monitoring objectives and approaches. Additional discussion on data quality objectives is included in the QAPP in Appendix A.

3.1 Monitoring Objectives

The main objective of long-term monitoring is to determine if the cap is performing the basic functions required to meet the Removal Action objectives. Those functions require that cap integrity, thickness, and consolidation be checked in response to physical processes such as erosion due to high flows, ice scour, flooding, and human activities. Therefore, monitoring will be performed to determine that the physical integrity of the cap is maintained such that it continues to isolate the active layer.

Chemical monitoring of porewater COPC concentrations will also be performed to evaluate if the cap is functioning as designed. The cap is designed to chemically isolate and prevent the breakthrough[1] of COPCs for at least 100 years; cap modeling indicates it will take significantly more than 250 years before any breakthrough will occur. Unless there is a significant breach to the physical integrity of the cap, the chemical isolation layer is expected to remain effective throughout the cap's lifetime.

These two lines of evidence (physical integrity and chemical isolation) provide direct empirical measurements to determine if the cap is functioning as designed and is therefore sufficient to provide protection of human health and the environment.

3.2 Monitoring Approach

The long-term monitoring will involve routine periodic monitoring of the physical integrity of the cap as well as event-based monitoring triggered by high flow events or anthropogenic disturbances that could affect the integrity of the cap. As required by Region 2, monitoring will also include routine periodic monitoring of the cap's chemical isolation effectiveness. The monitoring includes:

- Routine physical monitoring – approximately one to two years and five years after cap construction
- Event-based physical monitoring – after specified high flow events or anthropogenic disturbances during the first five years
- Routine chemical monitoring – approximately one to two years and five years after cap construction.

[1] For design purposes, breakthrough was defined as porewater seepage concentrations exceeding New Jersey Surface Water Quality Standards (CH2M Hill, 2013b). However, these values may not represent the long-term cap effectiveness criteria. It is anticipated that these values would be developed following completion of the Remedial Investigation/Feasibility Study (RI/FS) for the 17-mile LPRSA. Therefore, the chemical monitoring discussed in this LTMMP is to evaluate cap performance and is not considered to be compliance monitoring (see also QAPP Worksheet #9).

Modifications of the routine cap monitoring program will be evaluated after the Year 5 event and/or when a long-term monitoring plan is adapted for the larger LPRSA or as porewater monitoring techniques and technologies advance.

3.2.1 Routine Physical and Chemical Monitoring

As further discussed in Section 4, routine physical monitoring of the cap will be performed using bathymetric surveys, probing, and/or poling to evaluate cap integrity. The routine physical monitoring will commence approximately one year after completion of cap placement and then at five years after cap placement. The first post-construction bathymetry survey was completed in June 2015 (as shown in Figures 2 and 5) with probing commencing approximately one year after cap construction and extending into year 2. In addition, a visual inspection will be conducted annually at low tide during each of the first five years.

As further discussed in Section 5, routine chemical monitoring of the cap's chemical isolation effectiveness will be performed using passive in-situ porewater sampling methods (i.e., solid-phase microextraction [SPME] samplers), as directed by Region 2. The routine monitoring of the cap's chemical isolation effectiveness will be performed on the same schedule as the routine physical monitoring.

Two attempts to complete the first chemical monitoring event were made in 2015 from approximately 12 to 18 months after cap construction, and these attempts were mostly unsuccessful. A third successful attempt was completed in 2016 approximately two years following cap construction. The physical and chemical data obtained from the work completed in 2015 and 2016 will be presented in the data summary report for the first event as described in Section 7.

3.2.2 Event-Based Physical Monitoring

Event-based physical monitoring will be performed in addition to the routine monitoring following river flow events or anthropogenic disturbances that could affect the integrity of the cap. The RM 10.9 flows are approximated using discharge measurements from the United States Geological Survey (USGS) gage station at Little Falls and a drainage-area proration to estimate discharge at Dundee Dam (approximately 7 percent higher than Little Falls). Flow rates corresponding to recurrence intervals ranging from 5 years to 100 years are presented in Table 1 below.

Table 1 Summary of Designated Lower Passaic River Flow Events

Recurrence Interval	Discharge at Little Falls (cfs)	Approximate Discharge at Dundee Dam (cfs)
5 years	10,500	11,000
10 years	13,000	14,000
25 years	16,000	17,000
50 years	19,000	20,500
75 years	20,500	22,000
100 years	22,000	23,500

As the armor layer of the cap was designed for the 100-year event, the initial event-based physical monitoring will be performed within 1 to 2 months (when feasible) following a storm event where the river flow exceeds the 50-year return period flow as a conservative measure. Specifically, daily average flow exceeding 19,000 cfs at Little Falls will be used to trigger the initial event-based bathymetric survey. If the cap is shown to remain intact following the initial 50-year return period flow event, the second event-based monitoring will be triggered after the 75-year return period flow event is exceeded. Subsequent event-based physical monitoring will only be triggered each time the design (100 year) flow event is exceeded. If the initial or second event also exceeds the 100-year return period flow and the cap is shown to remain intact, subsequent event-based physical monitoring will only be triggered each time the 100-year flow event is exceeded.

As noted in the Final Design (CH2M Hill, 2013b), the cap is expected to remain generally intact even if the 100-year return period flow is exceeded. The velocities and associated erosive forces across the river are not uniform; the highest velocities used for design occur over only small portions of the cap. Thus, the vast majority of the cap is expected to withstand flows that are higher than the 100-year return period flood.

In addition to flow events, nearby in-river construction activities (e.g., bridge or utilities) or anthropogenic disturbances (e.g., vessel grounding) that could directly or indirectly negatively impact the cap's physical integrity and/or cause significant cap erosion can trigger monitoring.

A significant cap elevation differential (i.e., detectable within the sensitivity of the bathymetric survey) between the previous hydrographic surveys and the most recent hydrographic survey will require evaluation and discussion with Region 2.

4.0 Physical Monitoring

The cap is designed to effectively resist physical processes that can affect the cap integrity and thickness. In addition to annual visual inspections, physical monitoring will be performed to determine if the physical structure of the cap remains intact and the overall cap continues to perform its function to protect the active layer and isolate the underlying contaminated sediment. Bathymetric surveys and other techniques such as probing and poling will be used to monitor the physical integrity of the armor layer of the cap and presence of sediment deposited on the cap. Additional discussion on monitoring procedures is included in the QAPP in Appendix A.

4.1 Bathymetric Surveys

The routine monitoring bathymetric surveys (in Years 1 and 5) and event-based monitoring, if needed, will be performed using single beam systems in accordance with the QAPP. Single beam data will be collected as the majority of the cap is in areas of shallow water depth where the multi-beam equipment cannot operate. The single beam survey will be performed consistent with previous Region 2-approved single beam surveys performed by the CPG. The accuracy of the single beam bathymetric survey of +/- 0.3 meters is the accuracy for bathymetry surveys used for the project. If more accurate survey methods become available and are implementable at RM 10.9, they will be used, if appropriate, to help reduce the uncertainty associated with the currently accepted bathymetric measurements of cap elevation. The bathymetry QAPP (included as an appendix of the QAPP in Appendix A of this LTMMP) specifies survey procedures, performance criteria, calibration procedures, and data quality assurance and management following the specifications of the Hydrographic Survey Manual, EM 1110-2-1003 (United States Army Corps of Engineers [USACE], 2013).

The bathymetric surveys will be conducted of the cap area (including the utility corridor where a cap could not be placed) and will extend from approximately 100 feet upstream and downstream of the cap and from the eastern shoreline (estimated at the mid-tide elevation) to 100 feet from the edge of the cap into the river channel. Figure 4 shows the area of the proposed bathymetric surveys. The bathymetric surveys will be conducted at a time as close to high tide as possible in order to extend the survey lines as close to the high water line over the capped area as can be obtained while maintaining the safe navigation of the survey vessel and ensure lock on the differential global positioning system (GPS) satellite constellation.

The bathymetric survey data will be collected along the same transects for each survey to the extent possible to aid in data comparisons. It is anticipated that single beam cross sections will be taken at 25-foot intervals and perpendicular to the channel centerline and with three tie-lines running parallel to the shore.

4.2 Probing and Poling

Probing of cap layer thicknesses will be conducted at each of the ten chemical monitoring stations at low tide (see Section 5). Other locations may be probed if significant decreases (greater than 50 percent) are observed in the armor layer thickness as compared to the as-constructed thickness. Based on the results of preliminary probing conducted in April 2015, the probing (utilizing a drive point probe advanced with a slide hammer) will be able to determine the thickness of the combined habitat layer above the armor layer and any sediment deposited since cap construction as well as the thickness of the armor layer. Probing will be supplemented by poling inspections, as needed, to determine the presence of gravel/stone based upon pole refusal and measurements to the top of the armor layer. Poling is intended to confirm the presence of the armor layer, as well as the thickness of habitat layer material and/or accumulated sediment if present, but is not intended to determine the thickness of the armor layer.

Probing and poling procedures are further described in the QAPP in Appendix A.

4.3 Armor Layer Assessment

Visual inspections and bathymetric changes over time will be used to identify potential changes in the physical integrity of the armor layer or the overall cap. During interpretation of the bathymetric survey data, consolidation of soft sediment beneath the engineered cap will also be considered. However, it is anticipated that the majority of cap consolidation will occur in the first year following construction. The extent of consolidation depends on the thickness of cap, the elapsed time after cap placement, the thickness of soft sediment beneath the cap, and initial conditions and consolidation properties of the sediment. Consolidation of soft sediment beneath the cap is a long-term process, although most of the consolidation is expected to occur within the first year after cap placement. The physical cap monitoring will also detect if uneven consolidation beneath the cap is sufficient to affect cap integrity.

If bathymetric survey and probing data indicate significant erosion through the armor layer covering a contiguous area greater than 5 percent of the total cap area (which would represent an area of approximately 100 feet by 100 feet in size) or in any area in which the armor stone has been eroded to the geotextile fabric, the affected cap area will be assessed by additional probing, poling and/or diver inspection.

The physical integrity of the cap will be evaluated based on two decision criteria: armor layer thickness (based on probing) and cap elevation (based on bathymetry). The cap surface elevation can decrease for two primary reasons: cap erosion and cap consolidation. If the cap surface elevation has dropped, but the armor layer thickness is intact (less than a 50 percent decrease in comparison to as-constructed cap thickness) then the drop in cap elevation could be attributed to cap consolidation. Conversely, if the cap surface elevation has dropped and the armor layer thickness has decreased (greater than a 50 percent decrease in comparison to as-constructed cap thickness is used as a conservative trigger), then the drop in cap elevation may be attributed, in part, to armor layer erosion. Potential response actions are discussed in Section 6.

5.0 Chemical Performance Monitoring

Chemical performance monitoring will be conducted to determine if the cap chemically isolates the environment from COPCs remaining in the post-dredge sediments. The chemical performance data will determine whether the cap is performing as designed. Chemical monitoring of in-situ porewater in underlying sediments and the cap layers will provide the basis to confirm the cap model predictions. In addition, chemical analysis of surface sediments will be used to evaluate potential recontamination on the cap surface from newly-deposited sediment on top of the engineered cap.

A summary of the monitoring methods and approaches is provided below. Additional discussion on monitoring methods, including standard operating procedures (SOPs), as well as data analyses is included in the QAPP in Appendix A.

5.1 Porewater Sampling

The main cause of potential chemical migration through the engineered cap is from advection of porewater due to changes in effective stress, waves, groundwater flux, and consolidation. To monitor for the chemical isolation effectiveness of the sand/active layer, porewater will be monitored in the underlying sediment, at the top of the sand/active layer, and in the armor layer, as requested by Region 2. Due to the presence, size, and configuration of the armor stone, the Henry samplers, which are typically used for passive porewater SPME sampling, could not be inserted directly and an alternative insertion technique was used. This alternative method included driving an AMS drive point tip on a drive extension pipe which allowed insertion of modified Henry samplers (additional slots cut into the sampler to increase the slotted portion of the sampler to be the same as the SPME fiber length and removal of the “T” cross bar to allow sealing of the drive extension pipe) with the SPME fiber array on a steel rod, as described below in Section 5.1.2 and in more detail in the “Installation and Recovery of SPME Sampling Device in Sediment SOP” in the QAPP. As a result, three discrete samplers are used at each location to prevent cross contamination between samplers at each of the three depths. As further discussed below and in the QAPP, sampling procedures have been developed and refined based on the thicknesses and characteristics of each of the cap layers as well as the deposition of new sediment on the cap.

The three COPCs to be analyzed (2,3,7,8-TCDD, PCB 52, and phenanthrene) are the three organic COPCs used to design the cap. As further discussed in the Final Design (CH2M Hill, 2013b), these COPCs were selected based on their toxicity and/or mobility. As further discussed in the QAPP, High Resolution Gas Chromatography and High Resolution Mass Spectrometry will be used to maximize the analytical sensitivity.

5.1.1 Passive Sampling Methods

As directed by Region 2, passive in-situ porewater sampling methods will be used during the routine chemical monitoring activities to detect and quantify porewater concentrations of select COPCs within the cap and underlying sediments. These methods greatly reduce the need for large volumes of sediment porewater, which is inherently more difficult to collect, ship, and prepare for analysis.

At the direction of Region 2, passive sampling using polymer coating on SPME fibers was selected in order to increase the probability that only the COPCs actually dissolved in porewater are measured.

The SPME sampling devices consist of fused silica fibers coated with a polydimethylsiloxane (PDMS) sorbent. When these fibers are exposed to the media (e.g., porewater) organic COPCs present in the media partition onto the coating until equilibrium is attained. After the SPME sampling devices are retrieved, the fibers are sent for laboratory analysis.

Passive sampling attempts to reduce matrix interferences and potentially eliminates the whole water analysis problem of including colloidally bound and COPCs sorbed to organic carbon. When the COPCs have equilibrated between the source sediment, dissolved organic carbon, porewater, and the polymer sorbent on the SPME fibers, then the polymer sorbent concentration can be used to estimate the porewater concentration if reliable partition coefficients for the polymer are available (see Section 5.1.3). Passive sampling improves the sensitivity of porewater analysis for hydrophobic COPCs because the polymer partitioning coefficient acts as a multiplier, lowering detection limits. The thin polymer coating on the SPME fiber usually equilibrates within a few weeks and negligibly depletes the surrounding porewater of COPCs (Ghosh, et al., 2014). The COPCs are expected to be equilibrated within 28 days based on experimental evidence for PDMS-coated fibers from previous research (USEPA, 2012; SERDP/ESTCP/USEPA, 2016; Witt et al., 2013). Although samplers are often deployed for 28 days, more hydrophobic contaminants may require more than 28 days to achieve equilibrium (USEPA, 2012). Consequently, the planned minimum time for sampler deployment has been extended to 60 days to allow for additional time to either attain or more closely approximate equilibrium with the in situ porewater. Deployment may exceed 60 days depending on the optimal tide conditions for placement and retrieval. Given the SPME fiber sorbent thickness and deployment time of at least 60 days, impregnation of fibers with performance reference compounds to verify equilibration is not included in this monitoring.

In addition, as further discussed in the QAPP, the screen interval, total length of SPME fibers, and fiber PDMS sorbent coating thickness were selected to maximize sorbent mass resulting in sufficiently low detection limits to satisfy data quality objectives.

5.1.2 Sample Locations and Depths

Sample locations were selected to be spatially distributed across the cap area, and include a location of higher upwelling, locations where sediment samples beneath the cap exhibited relatively higher concentrations of the COPCs compared to other areas of the cap, and locations in areas adjacent to the utility area where a cap was not installed (see QAPP Worksheet #18 and Figures 2 through 5 in the QAPP). Three additional locations selected by Region 2 are also included for a total of ten locations. These stations were added based on contaminant concentration, groundwater flux rate, and spatial distribution. These proposed locations are shown on Figure 5 in this LTMMP. Field conditions and health and safety requirements may require modifying the preselected sample locations. If during either the routine long-term monitoring or event-based monitoring a breach in the integrity of the cap is identified, sampling in areas other than the currently designated locations will be considered.

GPS coordinates and physical markers (metal plates) will be used to re-occupy stations. A 4-inch diameter metal plate will be attached to each of the three samplers at each station during deployment and a metal detector will be used, if needed, to locate the sampler for retrieval. At each station, one of the three metal plates will remain after sampler retrieval to assist in re-occupying the station in future years, if needed.

All site sampling activities will be conducted at low tide when the sampling locations are accessible by foot. Based on the results of the preliminary probing conducted in April 2015 and the presence of the armor and geotextile layers in the cap design, insertion of the samplers using either a boat-based platform or divers was deemed not feasible by the CPG because (1) a slide hammer is required to advance the probe and sampler through the armor and geotextile layers, which is not feasible with divers, (2) the current and shallow water also make the use of divers not feasible, and (3) the delicate nature, small scale, and the need to install multiple samplers in a small area to finely defined depths through the armor and geotextile layers while holding a sample vessel on station makes use of a boat-based platform not feasible. Therefore, the preferred method to install the sampling devices is to access the locations on foot during a low tide. For this reason, some locations may not be accessible at the time of sampling and may need to be modified at the time of sampler placement. This LTMMP was prepared after the initial deployment of SPMEs in 2015, at which time eight of the ten locations were accessed and monitored. The two northernmost locations could not be accessed on foot at that time due to restrictions along the shoreline. A boat was subsequently used to access these two locations in 2016 when all ten stations were successfully occupied and sampled.

Samples will be collected from the SPME samplers through an approximate 5-inch screened interval (based on screened interval of sampling device being used [AMS Soil Vapor Probe and Henry Sampler], cap layer thicknesses, and length of SPME fibers required for analysis) at three depth intervals: underlying sediments (approximately 31 to 36 inches below the top of the cap), cap active layer (approximately 15 to 20 inches below the top of the cap), and armor layer (approximately 2 to 7 inches below the top of the cap). These depths are approximate and may be adjusted following review of the bathymetric survey results and probing data. At each location each sampler will be deployed in a separate modified Henry sampler to avoid cross-contamination between depth intervals. The samplers will be inserted into the cap in a triangular pattern (one for each of the three depths) as close as possible, and within approximately 2 feet of each other. The precise location of the samplers will depend on the results of the probing and ability to penetrate to the desired depth. Probing cannot distinguish between the active layer and underlying sediments, so the top of the screened interval of the active layer SPME sampler will be installed immediately (e.g., 1 inch) below the armor layer/geotextile and the top of the screened interval of the underlying sediment SPME sampler will be installed at a depth below the geotextile based on the as-constructed thickness of the active layer (approximately 10 inches) plus 6 inches.

5.1.3 Porewater Concentration Calculation

As further discussed in the QAPP, SPME sampler analyte mass will be converted to porewater concentrations using published literature values for partition coefficients for the PDMS sorbent on the SPME fibers using the following formula:

$$C_{pw} = C_{pdms} / K_{pw}$$

where C_{pw} is the porewater concentration, C_{pdms} is the analyte mass divided by the PDMS sorbent mass (sorbent mass is derived from the SPME fiber length, coating thickness, and sorbent density), and K_{pw} is the PDMS partition coefficient based on literature values as presented in QAPP Worksheet #11.

5.2 Sediment Sampling

Surface sediment samples will be collected at the same locations as the porewater samples. Surface sediment samples will be collected from the soft sediments deposited on top of the sand habitat layer and will include collection of sediment from the full thickness of the soft sediments above the habitat layer. If soft sediments are not present at a location, or cannot be distinguished from the sand habitat layer, the surface sediment samples will be collected from the sediment surface (0 to 3 inches) to focus the sampling at the sediment surface where potential newly deposited sediment may be present. These sediment samples will be collected as close as possible to the armor layer SPME location, but not more than 8 inches from the armor layer passive samplers. Surface sediment samples will be collected using grab sample techniques similar to those used during the RM 10.9 Characterization. Samples will be collected immediately prior to the retrieval of SPME fibers and will be analyzed for the same three COPCs (2,3,7,8-TCDD, PCB 52, and phenanthrene) as well as total organic carbon (TOC).

6.0 Cap Maintenance

The maintenance of the cap includes repair, enhancement, or other contingency actions as appropriate depending upon physical monitoring data or other information that indicate a pattern of cap degradation. Response actions to repair the cap would typically only be performed after the cause of cap degradation has been determined. If the cause of any cap damage or degradation cannot be determined in a reasonable timeframe, response actions will be evaluated and implemented, as feasible.

6.1 Cap Maintenance Trigger

A cap maintenance response action will be triggered if the physical monitoring data indicate that a contiguous area greater than 5 percent of the total cap area (which would represent an area of approximately 100 feet by 100 feet in size) has eroded more than 50 percent of the armor layer thickness or in any area in which the armor stone has been eroded to the geotextile fabric.

6.2 Potential Response Actions

If a cap maintenance response action is triggered, the possible response actions may include:

- Increase the frequency of cap monitoring in the affected area
- Repair of affected area
- Enhance the armor layer in affected area
- Enact institutional controls or other means to help minimize further cap erosion (e.g., prohibiting the construction of in-water structures near the cap).

Additional supplemental evaluations may be performed to identify which additional response activities may be appropriate for consideration. If monitoring or other information shows a pattern of cap degradation in multiple areas and the causes have been determined, then additional response activities may be considered.

7.0 Reporting

Detailed data summary reports will be submitted following completion of each of the physical and chemical monitoring events, and after any event-based monitoring. It is anticipated that the reports will include presentations of physical and chemical monitoring results as well as interpretations of the data to document cap performance, and include:

- Results of physical monitoring (bathymetric surveys, probing and/or poling) and visual inspections
- Results of chemical monitoring (porewater and sediment analytical results) and associated data usability assessments as per the QAPP
- Maps of sample locations and observations
- Calculations of porewater concentrations based on the SPME data (including supporting information such as SPME fiber length recovered and coating thickness)
- Photos and/or videos of cap inspections and monitoring
- Other information as needed to fully understand the monitoring event (e.g., condition of SPME fibers after retrieval, deployment durations)
- Evaluation of cap performance based on both physical and chemical monitoring results (i.e., armor layer assessment, comparison of porewater data to cap model projections)
- Recommendations for evaluation of potential response actions, as needed
- Recommendations for modifications to the LTMMP and/or QAPP, as needed.

The schedule for the submission of the reports will be discussed with Region 2 following the completion of the initial and Year 5 events.

8.0 References

AECOM. 2017. Quality Assurance Project Plan for the Lower Passaic River Restoration Project: River Mile 10.9 Post-Construction Monitoring. Revision 4. January.

CH2M Hill. 2013a. Draft River Mile 10.9 Removal Action Long-Term Cap Monitoring and Maintenance Plan – Revision1, Lower Passaic River Study Area. May.

CH2M Hill. 2013b. River Mile 10.9 Final Design Report, Lower Passaic River Study Area. July.

CH2M Hill. [in preparation]. River Mile 10.9 Removal Action Final Construction Report, Lower Passaic River Study Area. August 2014.

Ghosh, U., S.K. Driscoll, R.M. Burgess, M.T.O. Jonker, D. Reible, F. Gobas, Y Choi, S.E. Apitz, K.A. Maruya, W.R. Gala, M. Mortimer, and C. Beegan. 2014. *Passive Sampling Methods for Contaminated Sediments: Practical Guidance for Selection, Calibration, and Implementation*, Integrated Environmental Assessment and Management. 10(2): 210-223. Supplemental Information. 2014.

SERDP/ESTCP/USEPA. 2016. Laboratory, Field, and Analytical Procedures for Using Passive Sampling in the Evaluation of Contaminated Sediments: User's Manual. Draft. EPA/600/XX-15/071. Office of Research and Development, Washington, DC 20460. May.

USACE. 2013. Engineering and Design – Hydrographic Survey Manual, EM 1110-2-1003.

USEPA (U.S. Environmental Protection Agency). 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. EPA-540-R-05-012, Office of Solid Waste and Emergency Response, OSWER 9355.0-85. December.

USEPA. 2012. Guidelines for Using Passive Samplers to Monitor Organic Contaminants at Superfund Sediment Sites, OSWER Directive 9200.1-110 FS. December.

USEPA Region 2. 2012a. Diamond Alkali, Lower Passaic River Study Area − River Mile 10.9 Administrative Settlement Agreement and Order on Consent for Removal Action. May 21 (effective June 18).

USEPA Region 2. 2012b. Action Memorandum/Enforcement: Determination of Need to Conduct a CERCLA Time Critical Removal Action at the Diamond Alkali Superfund Site, Lower Passaic River Study Area, River Mile 10.9 Removal Area. May 21.

Witt, G., S.C. Lang, D. Ullmann, G. Schaffrath, D. Schulz-Bull, and P. Mayer. 2013. *Passive Equilibrium Sampler for in Situ Measurements of Freely Dissolved Concentrations of Hydrophobic Organic Chemicals in Sediments*. Environ. Sci. Technol. 2013, 47, 7830−7839.

Figures

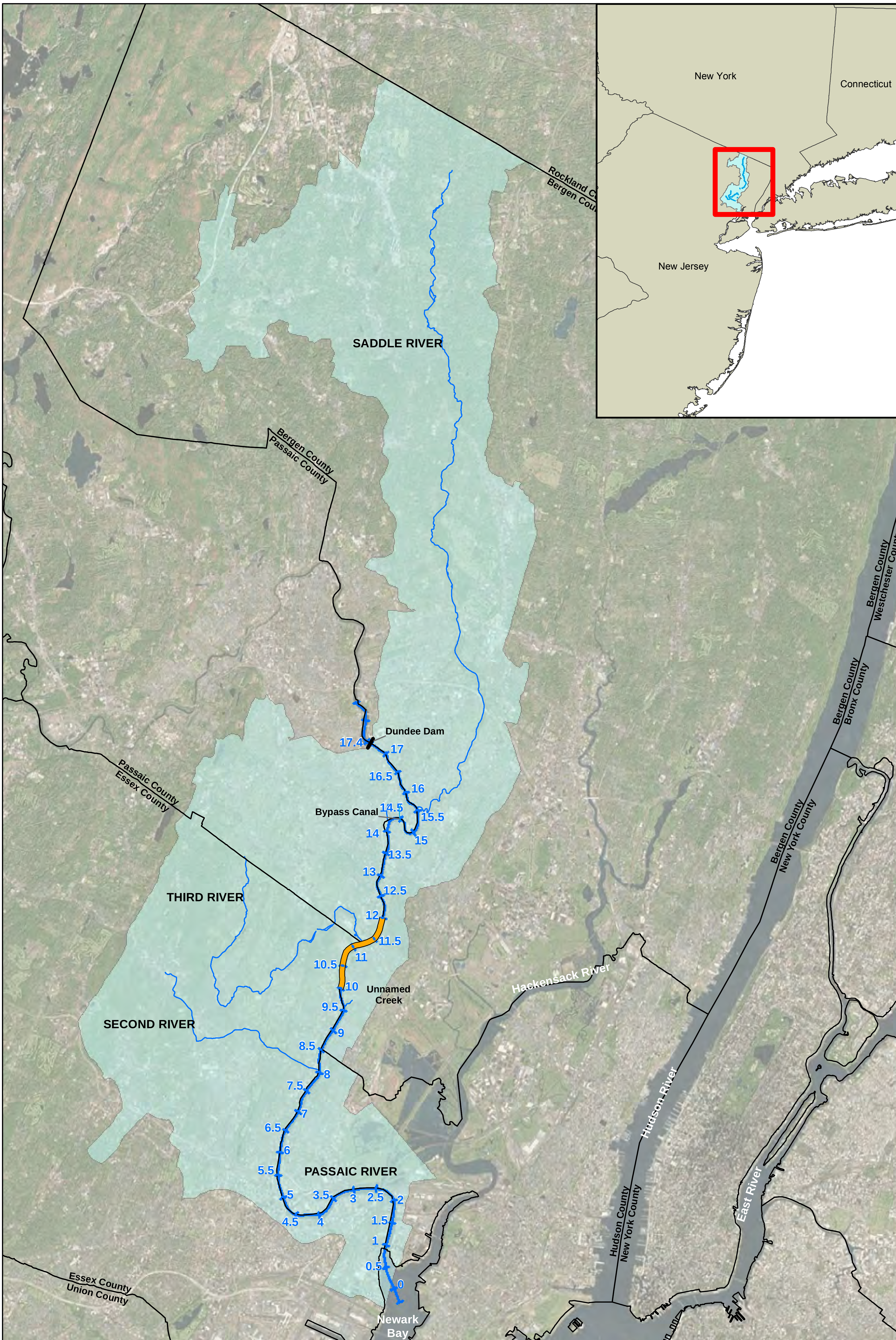

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Figure 1 Lower Passaic River and RM 10.9 Study Area

0 1.2 2.4 3.6 4.8 6 Miles

0.5 Passaic River measured centerline (miles)

Passaic River Tributaries

RM 10.9 Study Area

Lower Passaic River Study Area

County Boundary

Note:
1. The RM 10.9 Study Area extends from RM 10 to RM 12
2. The RM 10.9 dredge/cap area extends from RM 10.75 to RM 11.24

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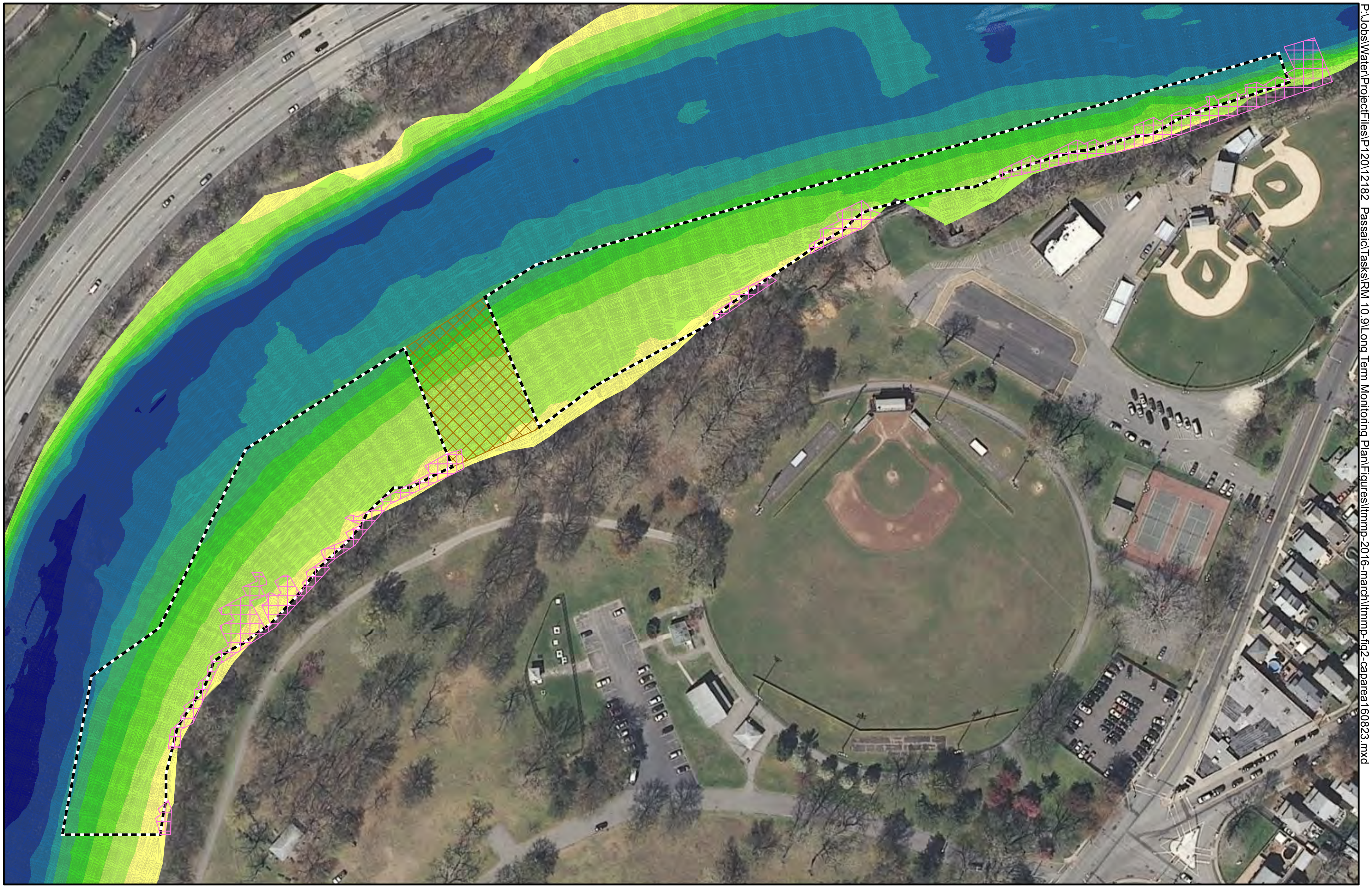
January 2017

Map Projection: NJ State Plane, NAD 83 Feet



Dredge/Cap Area
No Dredge Area
Hard Pan

Elevation (feet NGVD29)

0.08 - 2.29
-2.13 - 0.08
-4.34 - -2.13
-6.55 - -4.34
-8.76 - -6.55
-10.97 - -8.76
-13.18 - -10.97
-15.39 - -13.18
-17.6 - -15.39

Bathymetry survey by GBA, June 2015

Note:
Cap Type A placed in all areas within the Dredge/Cap Area, except hard pan areas where Cap Type B was placed (see Figure 3).

0 50 100 200 300 Feet

N

Figure 2
RM 10.9 Dredge and Cap Area

January 2017

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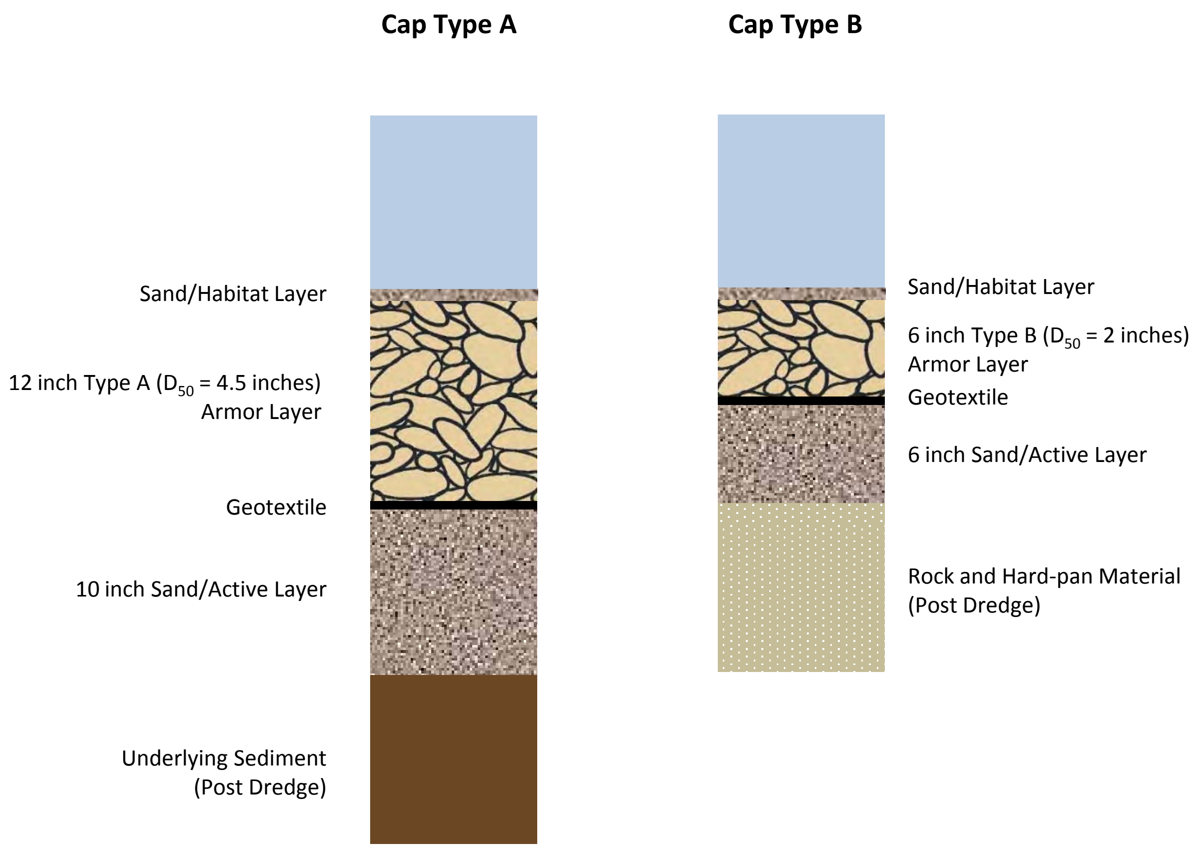

Figure 3. Typical Cap Sections

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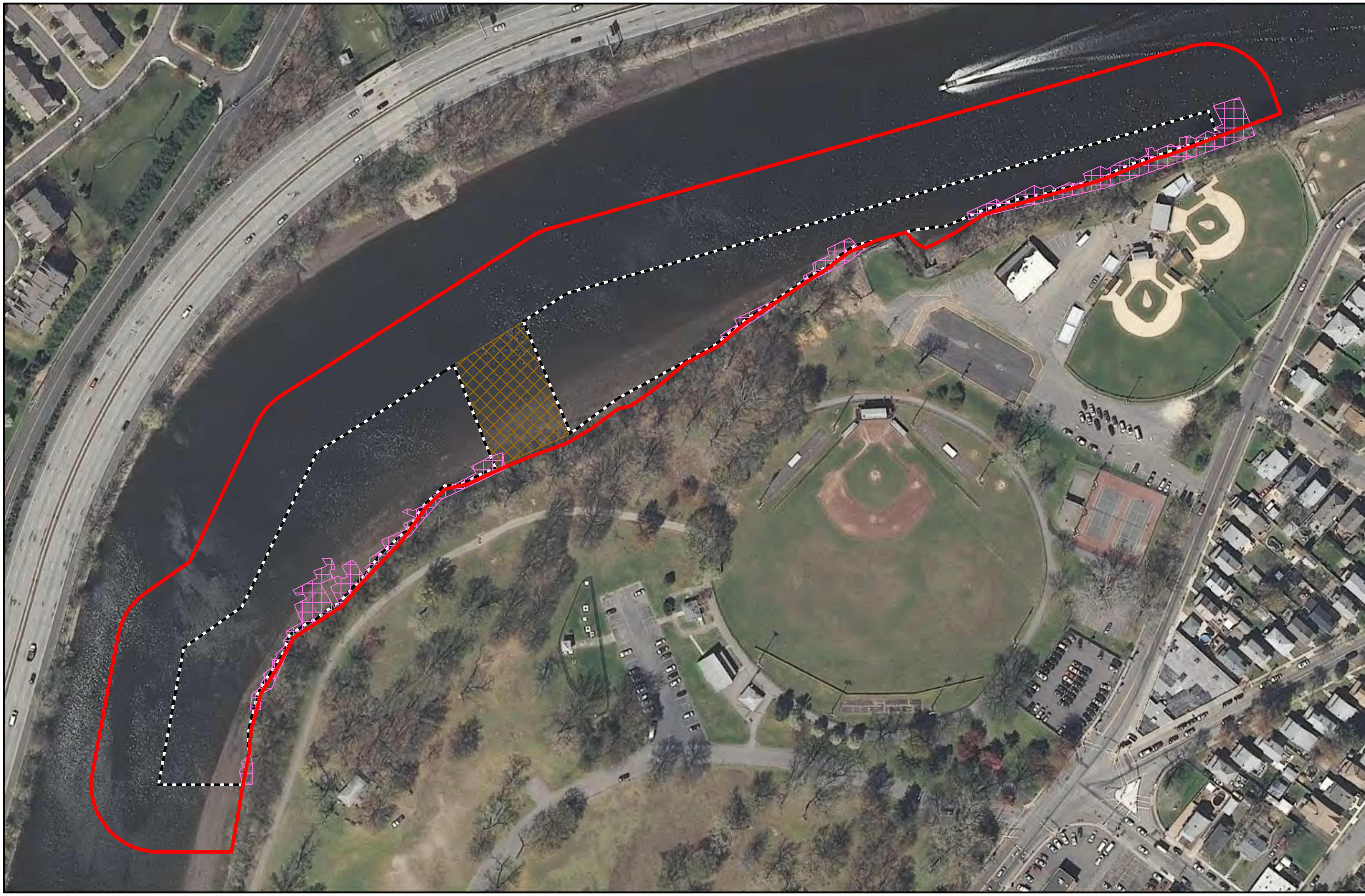

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Proposed Bathymetry

Dredge/Cap Area

No Dredge Area

Hard Pan

0 50 100 200 300 400 Feet

N

Figure 4
Proposed Bathymetry Area

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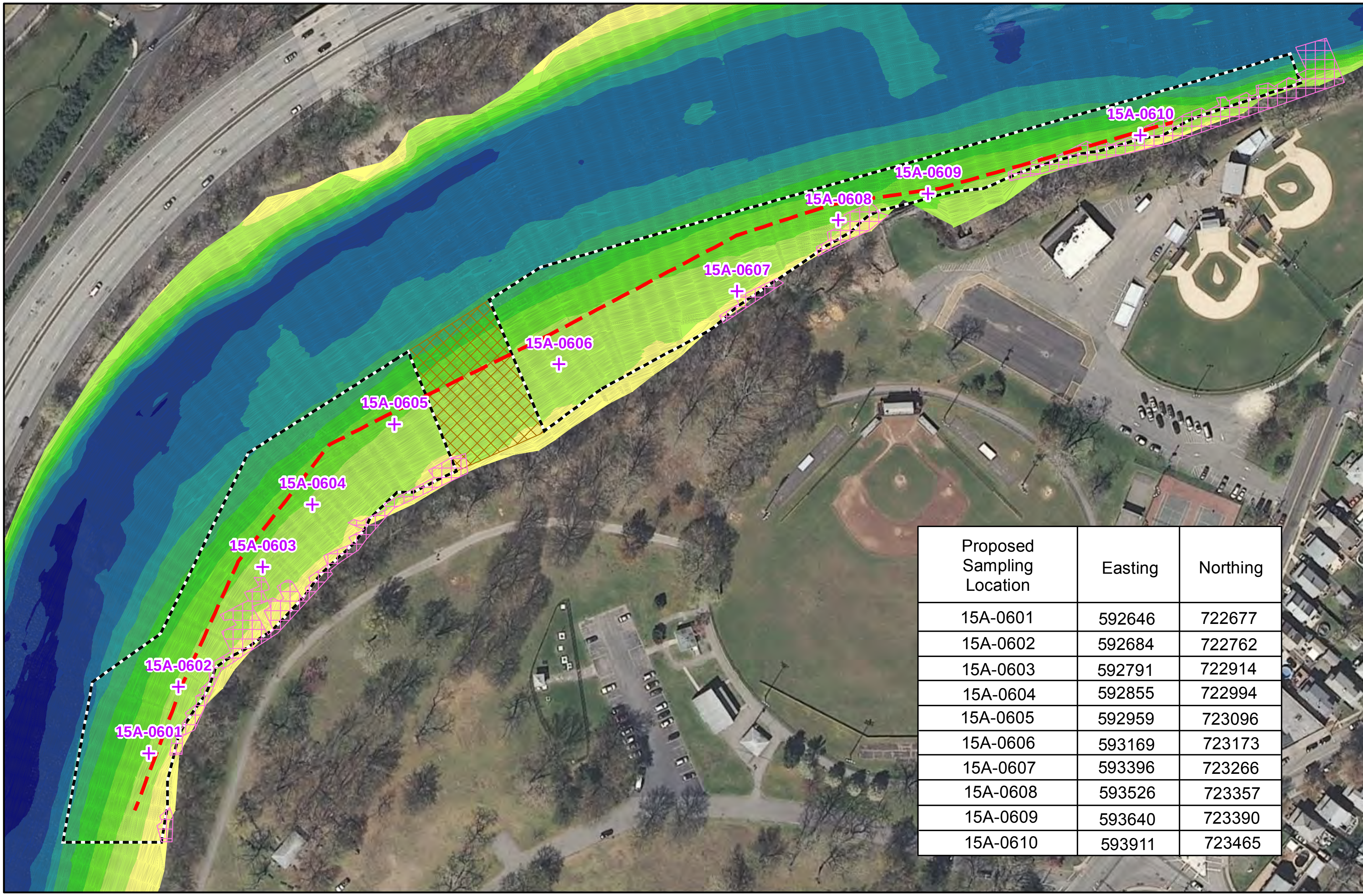

Proposed Sampling Location	Easting	Northing
15A-0601	592646	722677
15A-0602	592684	722762
15A-0603	592791	722914
15A-0604	592855	722994
15A-0605	592959	723096
15A-0606	593169	723173
15A-0607	593396	723266
15A-0608	593526	723357
15A-0609	593640	723390
15A-0610	593911	723465

+ Proposed Porewater and Surface Sediment Sampling Location
Approximate Low Water Line, 9/29/15 at a tide elevation of -0.95 ft relative to MLLW
Dredge/Cap Area
No Dredge Area
Hard Pan

0 50 100 200 300 Feet

N

Elevation (feet NGVD29)

- 0.08 - 2.29
- -2.13 - 0.08
- -4.34 - -2.13
- -6.55 - -4.34
- -8.76 - -6.55
- -10.97 - -8.76
- -13.18 - -10.97
- -15.39 - -13.18
- -17.6 - -15.39

Bathymetry survey by GBA, June 2015

Figure 5
Proposed Porewater and Surface Sediment Sampling Locations

January 2017

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Appendix A

RM 10.9 Post-Construction Monitoring Quality Assurance Project Plan